Methane Sulphonic Acid trend associated with Beryllium-10 and Solar Irradiance

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ABSTRACT

The solar activity has been propose as one of the main factors of the climatic variability. Also another type of processes, the biological ones, have been proposed as important factor in the climatic variation through the modification of the cloud albedo. In the present work we used the wavelet analysis to investigate the relation between the high latitude concentrations of Methane Sulphonic Acid (MSA), that is a product of marine seaweed and total solar irradiance (TSI) and Beryllium-10, an isotope that forms in the atmosphere and is a proxy of the cosmic rays. We found that the MSA presents in the 11 years sunspot cycle a negative correlation with the TSI and a positive correlation with Beryllium-10. Moreover, the Beryllium-10 presents a positive correlation with the MSA at 22 years.

Introduction

Solar radiation is the fundamental source of energy that drives the Earth's climate and sustains life. Due to the small change in TSI along the solar cycle, other solar-related phenomena have been explored in the context of the climate, in particular cosmic rays.

Cosmic rays are the main source of atmospheric ionization in the low marine atmosphere. Clouds have a major impact on the heat and radiation budget of the atmosphere through the albedo, however to form a cloud, water vapour requires a condensation nucleus on which to condensate.

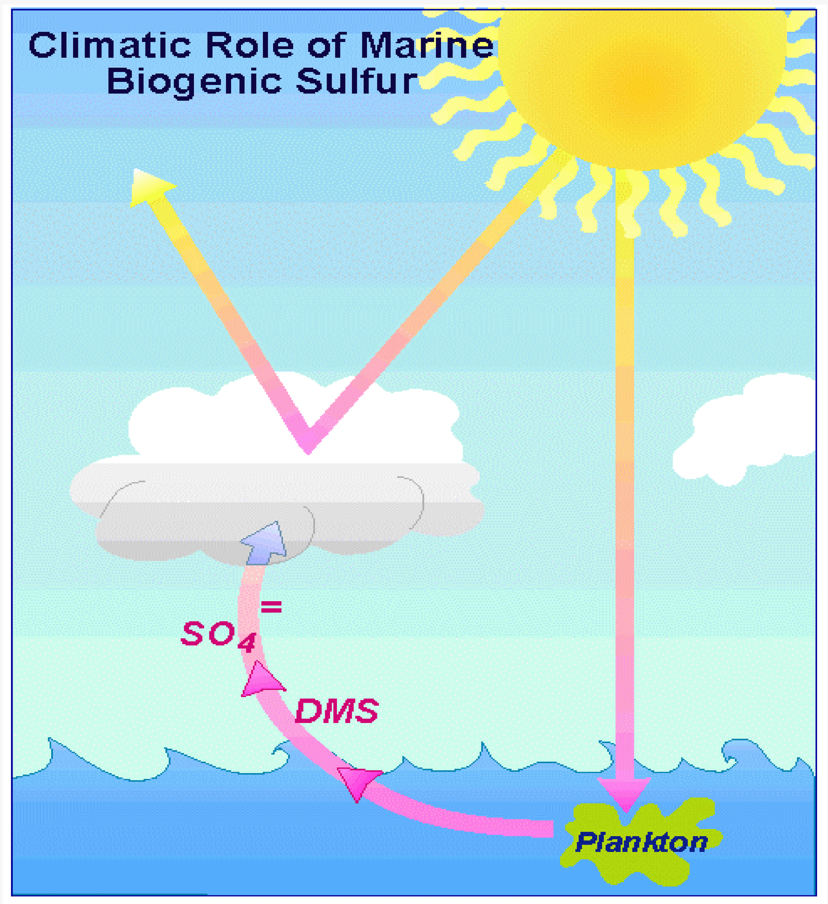

Figure 1. ***Hypothesized a climate feedback link where changes in cloud albedo and subsequent changes in surface temperature and/or solar radiation below clouds could affect the production of DMS by marine phytoplankton.***

DMS diffuses through the sea surface to the atmosphere where it is oxidized to form SO_2; this compound can be oxidized to H_2SO_4 that forms sulphate particles which act as CCN.

The DMS concentration is controlled by the phytoplankton biomass and by a web of ecological and biogeochemical processes driven by the geophysical context .

Data and Results

As the highest concentrations of DMS are in high latitude regions of both hemispheres, we use two annual concentration records of MSA from ice cores: the Arctic Svalbard (79°N, 16°E) set that extends from 1920 to 1995 and the Antarctic coastline Law Dome (66°S, 110°E) set from 1841 to 1995. Additionally we work with the TSI time series from 1860 to 2000 and two SST reconstructed time series (78°-80° N, 15°-17°E) (65°-67° S, 109°-111°E) that include the area of the MSA records. In order to analyze localized variations of power within a time series at different frequencies we apply the wavelet method, using the Morlet wavelet.

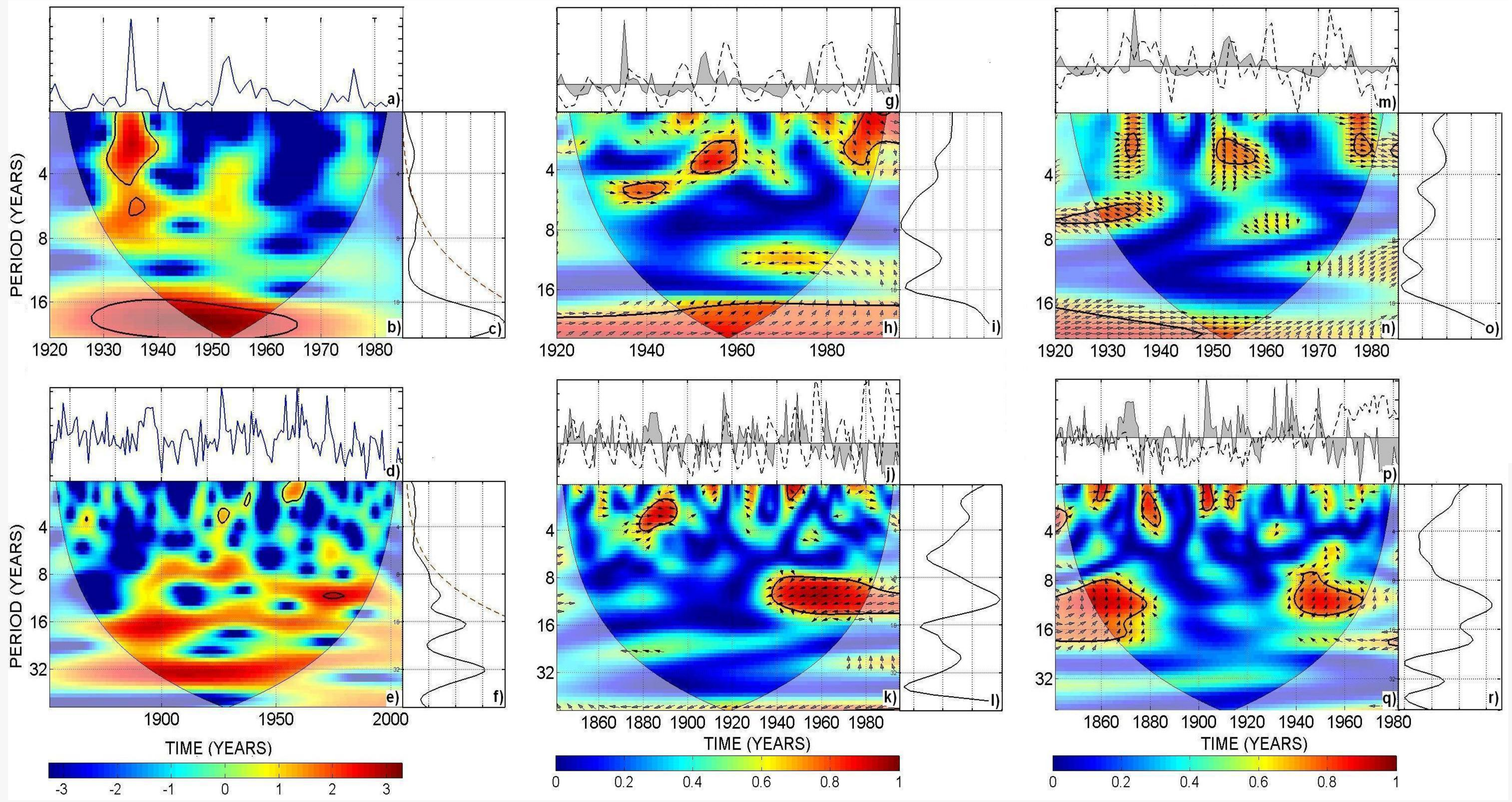

Figure 2. ***Wavelet and wavelet coherence analysis of the MSA time series. (a) North Pole MSA time series; (b) wavelet spectrum; (c) global wavelet spectrum; (d) South Pole MSA time series; (e) wavelet spectrum; (f) global wavelet spectrum; (g) TSI and North Pole MSA time series (shaded area); (h) wavelet coherence spectrum; (i) global wavelet coherence spectrum; (j) TSI and South Pole MSA time series (shaded area); (k) wavelet coherence spectrum; (l) global wavelet coherence spectrum; (m) North Pole MSA (shaded area) and SST time series; (n) wavelet coherence spectrum; (o) global wavelet coherence spectrum; (p) South Pole MSA (shaded area) and SST time series; (q) wavelet coherence spectrum; (r) global wavelet coherence spectrum The key for the arrows and the remarks on the wavelet spectra and the global spectra are the same.***

In the context of our results, if cosmic rays also contribute to alter cloud albedo, then their effect along the 11yrs sunspot cycle will reinforce the effect of the MSA as the cosmic ray flux is anticorrelated with the TSI. In this case, solar activity could influence climate through two mechanisms: indirectly through TSI and directly through cosmic ray flux (Beryllium-10).

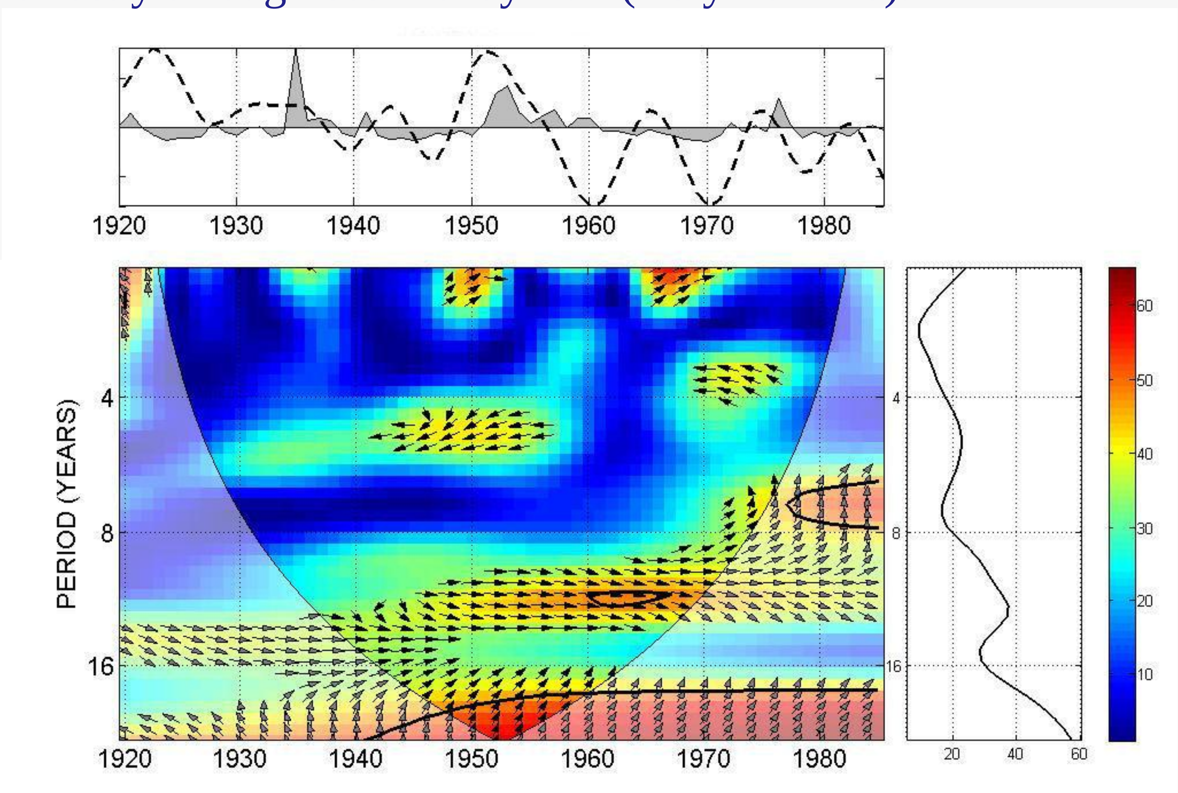

Figure 3. ***Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude north and Beryllium-10.***

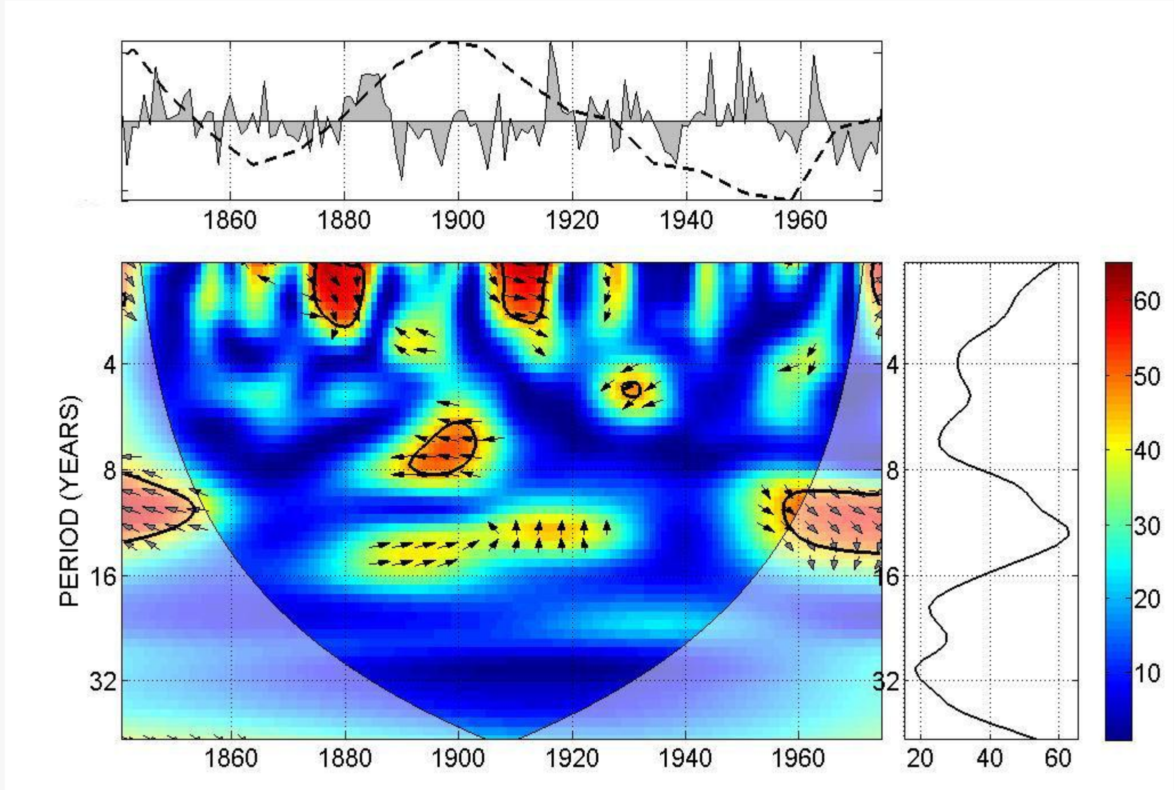

Figure 4. ***Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude south and Beryllium-10.***

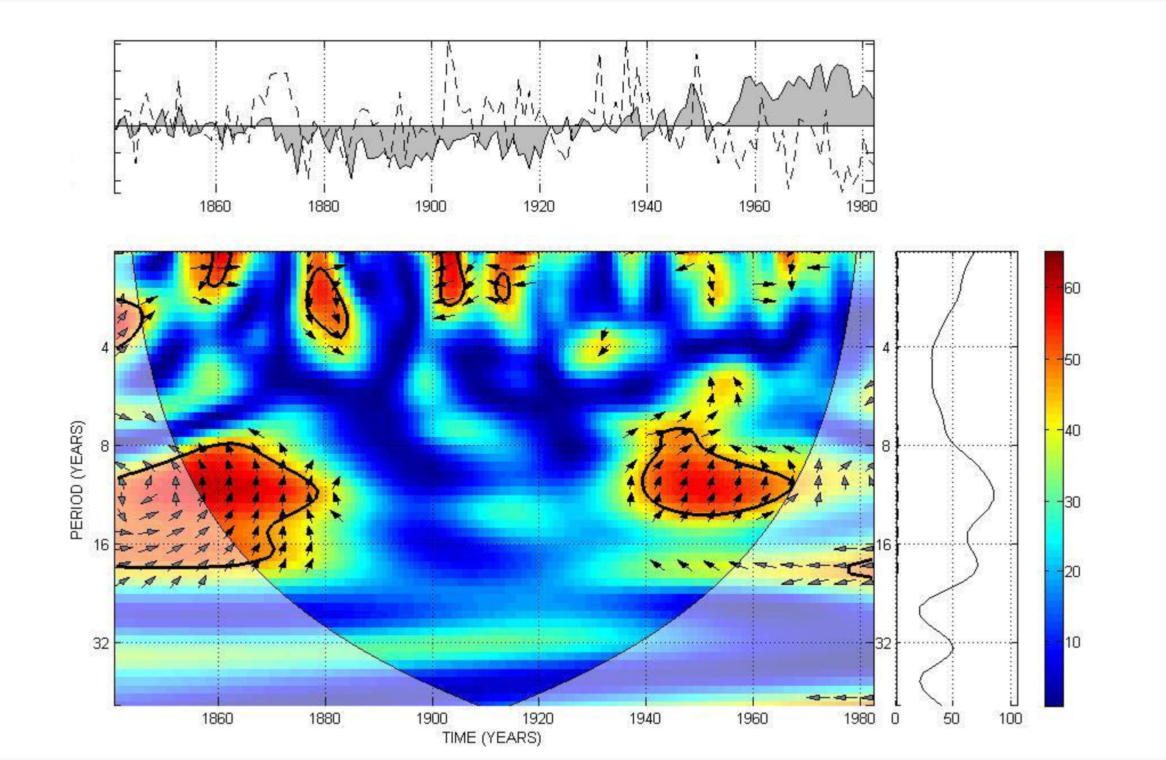

Figure 5. ***Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude north and Sea Surface Temperature (SST).***

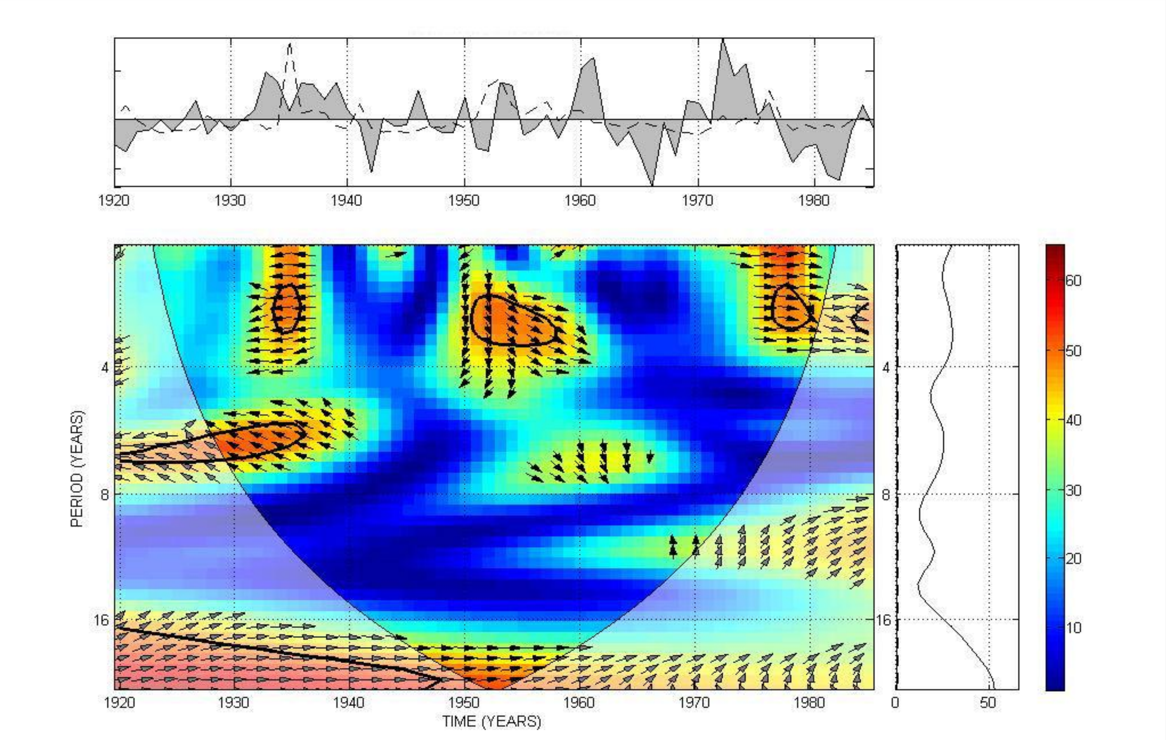

Figure 6. ***Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude south and Sea Surface Temperature (SST).***

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